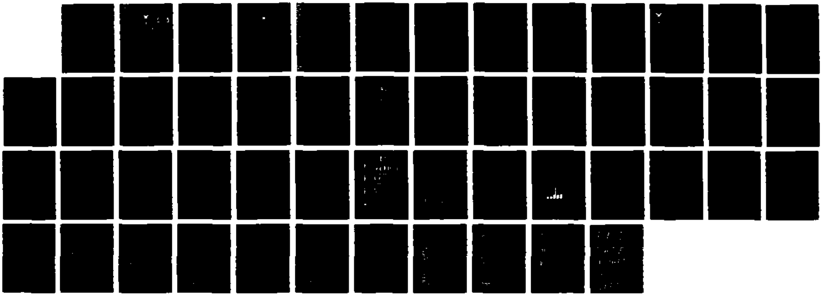
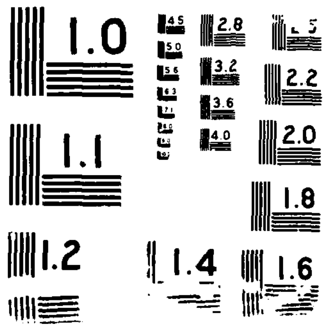
AD-A194 395 THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN(U) AIR COMMAND AND STAFF COLL MAXWELL AFB AL G E WALROND APR 88 ACSC-88-2705

1/1

UNCLASSIFIED F/G 1/3 NL




1.0
1.1
1.2
1.4
1.6
1.8
2.0
2.2
2.8
3.2
3.6
4.0

DTIC FILE COPY

(2)

AD-A194 395

DTIC
S ELECTE D
JUN 0 9 1988
H

AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN.

MAJOR GEORGE E. WALROND 88-2705

"insights into tomorrow"

88 6 6 075

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

DISCLAIMER

The views and conclusions expressed in this document are those of the author. They are not intended and should not be thought to represent official ideas, attitudes, or policies of any agency of the United States Government. The author has not had special access to official information or ideas and has employed only open-source material available to any writer on this subject.

This document is the property of the United States Government. It is available for distribution to the general public. A loan copy of the document may be obtained from the Air University Interlibrary Loan Service (AUL/LDEX, Maxwell AFB, Alabama, 36112-5564) or the Defense Technical Information Center. Request must include the author's name and complete title of the study.

This document may be reproduced for use in other research reports or educational pursuits contingent upon the following stipulations:

- Reproduction rights do not extend to any copyrighted material that may be contained in the research report.

- All reproduced copies must contain the following credit line: "Reprinted by permission of the Air Command and Staff College."

- All reproduced copies must contain the name(s) of the report's author(s).

- If format modification is necessary to better serve the user's needs, adjustments may be made to this report--this authorization does not extend to copyrighted information or material. The following statement must accompany the modified document: "Adapted from Air Command and Staff College Research Report ____(number)____ entitled ____(title)____ ________________ by ____(author)."________

- This notice must be included with any reproduced or adapted portions of this document.

REPORT NUMBER 88-2705

TITLE THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN.

AUTHOR(S) MAJOR GEORGE E. WALROND

FACULTY ADVISOR LT COL FREDERICK E. BASSETT, ACSC/EDJ

SPONSOR COLONEL LAWRENCE D. HOKANSON, HQ AFESC/RD

Submitted to the faculty in partial fulfillment of requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

A194 375

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT: STATEMENT "A" Approved for public release; Distribution is unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S): 88-2705

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION: ACSC/EDC

6b. OFFICE SYMBOL *(If applicable)*

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS *(City, State, and ZIP Code)*: Maxwell AFB AL 36112-5542

7b. ADDRESS *(City, State, and ZIP Code)*

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State, and ZIP Code)*

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*: THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN

12. PERSONAL AUTHOR(S): Walrond, George E. Major, USAF

13a. TYPE OF REPORT

13b. TIME COVERED FROM ______ TO ______

14. DATE OF REPORT *(Year, Month, Day)*: 1988 April

15. PAGE COUNT: 47

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The Advanced Tactical Fighter and any following fighters will be more reliable aircaft. This report investigates how much more reliable these aircraft will be and assesses the impact on aircraft maintenance facility design. It found that the intermediate level maintenance avionics and engine shops will be reduced in size and they could be eliminated.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT

☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☒ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL: ACSC/EDC Maxwell AFB AL 36112-5542

22b. TELEPHONE *(Include Area Code)*: (205) 293-2867

22c. OFFICE SYMBOL

DD Form 1473, JUN 86 — *Previous editions are obsolete.*

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

PREFACE

This report investigates how the increase in future fighter aircraft weapons systems reliability may impact the design of maintenance facilities. It investigates the technologies that will be incorporated in the Advanced Tactical Fighter (ATF) to determine if they will increase this aircraft's reliability. The paper briefly discusses the likelihood of a fighter being built that is capable of operating out of a very austere base. The report is intended to enlighten Air Force Civil Engineers on the developments in fighter aircraft.

Several people played a key role in the accomplishment of this study. Lt Col Tom May, the ATF Deputy Program Manager for Logistics, and Mr Jeffrey D. Kosan, the High Reliability Fighter Program manager, provided invaluable information about aircraft technology developments. Lt Col Fred Basset also provide key insights on fighter aircraft operations in Europe.

The information in this report can be used by Air Force Civil Engineering Planners to understand what the fighter force will look like over the next 25 years. This report will help them interface with aircraft designers in the development of facilities to support future fighter aircraft.

DTIC COPY INSPECTED

Accession For	
NTIS GRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

ABOUT THE AUTHOR

Major George E. Walrond received a Bachelor of Science in Civil Engineering and his commission in the Air Force in 1975 from the United States Air Force Academy. In 1984 he received a Master of Science in Civil Engineering from the Massachusetts Institute of Technology.

Major Walrond received his pilot wings in 1976. He is a command pilot with 2000 hours flying time. His primary weapons system is the KC-135 tanker aircraft. From 1984 to 1987 Major Walrond was a research engineer at the Air Force's Engineering and Services Laboratory located at Tyndall AFB, FL. He managed programs to develop computer simulations of aircraft responses to ground roughness and to determine if fighter aircraft could operate on debris-strewn runways. Major Walrond also served as the Chief of the Laboratory's Pavement Engineering Branch.

TABLE OF CONTENTS

CONTINUED

LIST OF ILLUSTRATIONS

TABLES

FIGURES

EXECUTIVE SUMMARY

Part of our College mission is distribution of the students' problem solving products to DoD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

"insights into tomorrow"

REPORT NUMBER 88-2705

AUTHOR(S) MAJOR GEORGE E. WALROND, USAF

TITLE THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN.

This research effort was done at the request of the Director of the Engineering and Services Laboratories, Headquarters Air Force Engineering and Services Center (HQ AFESC/RD), Tyndall AFB, Florida.

This report discusses future aircraft technology. It shows that a highly reliable aircraft weapons system can be produced today, and this will be reflected in the Advanced Tactical Fighter. This will likely result in the elimination of the intermediate level avionics shop. The engine intermediate shop will be reduced to half the size of the F-15 engine shop. Most of the maintenance on the ATF will be on equipment repair. There is not likely to be an aircraft capable of operating out of austere bases without maintenance facilities in the USAF inventory within the next 25 years. The fighter force over the next 25 years will be comprised mostly of F-15s, F-16s, and ATFs. The report recommends that the Air Force continue to build hardened

Chapter One

INTRODUCTION

Anyone following developments in fighter aircraft design, would be led to believe that the next generation of US Air Force fighter aircraft will be built with emphasis on weapons system reliability, ease of maintenance, and supportability in combat. These three elements designed into a fighter will facilitate its deployment to forward locations and make it a flexible weapons system to employ in combat. Increasing aircraft reliability reduces the number of maintenance actions required to keep the aircraft flying. It is also a force multiplier because the aircraft will be available to fly more sorties each day. Both of these spin-offs of increased reliability will affect the facilities designed, built, and maintained by Air Force Civil Engineers. The purpose of this report is to analyze how increased aircraft reliability will impact maintenance support facilities.

Technological advancements coupled with the "institutionalization" of good weapons system reliability and maintainability will result in the next generation fighter having greatly improved maintenance reliability.(29:2) As a result, the maintenance facilities required to support the next generation fighter will be smaller. This paper will support these assertions and show how the future maintenance facilities will compare with the facilities used to support current fighters.

OBJECTIVES

This research effort has three objectives. First, determine if future aircraft technologies will require any unique maintenance facilities. Second, determine if any of the existing facilities will have to be changed. Third, to find out if some of the requirements for current facilities will be eliminated.

In order to accomplish these objectives a comprehensive literature search of technical journals, technical reports in the Defense Technical Information Center, located in Cameron Station, Virginia, and books in the Air University Library, at Maxwell AFB, Alabama was made. The data from

the literature search has been supplemented with numerous interviews of Advanced Tactical Fighter (ATF) Program managers, the manager of the Air Force's High reliability Fighter (HRF) Program, officials from the Air Force Engineering and Services Laboratory, and officers working in the Office of the Special Assistant for Reliability and Maintainability (HQ USAF/LE-RD). Examples of systems management have been provided by the author.

BACKGROUND

This research effort was done at the request of the Director of the Engineering and Services Laboratories (ESL), Headquarters Air Force Engineering and Services Center (HQ AFESC/RD), Tyndall AFB, Florida. The ESL does research in environmental engineering, facility construction, pavement engineering, and fire protection. It has been heavily involved in air base operability research and is finishing a 10 year rapid runway repair research and development effort in response to Tactical Air Forces Statement of Need 319-79 (SECRET). This statement of need directed research in the design of systems to accomplish rapid runway repair, rapid facility repair, expedient utility repair, fire fighting, and unexploded ordnance protection.

Air Force Civil Engineers want to know how the increase in future fighter aircraft reliability will affect the aircraft maintenance support facilities. This is important to the civil engineers for two reasons. First, officials at the Air Force Engineering and Services Center point out that hardened maintenance facilities needed in Europe are very expensive to build, as exemplified by the $30 million intermediate level maintenance facility recently completed at Ramstein Air Base, Germany. (40:--) Large hardened facilities, once in place, are there to stay, and the Air Force does not want to make any mistakes with this type of construction. Second, there have been recent examples of aircraft systems designs that have had a major impact on the environment and the base infrastructure.

An example of an environmental concern is the hydrazine used to power the F-16's emergency power unit is a carcinogen. Air Force civil engineers had to insure that the equipment and procedures required to protect personnel and the environment from hydrazine were in place to support F-16 operations. The civil engineers would prefer that an alternative to the hydrazine powered generator be used. (33:--) A second example that affected the base infrastructure is the asphalt concrete rutting caused by high pressure F-15 tires. Conformal fuel tanks were installed on the F-15 which allowed the aircraft's gross weight to be increased by approximately 10,000 pounds. The tire deflection limits were kept constant by increasing

the tire pressure to above 300 pounds per square inch. The increase in weight and tire pressure increased the tire to pavement contact pressures, causing rutting. The Air Force is faced with possible reductions in pavement lifes at F-15 bases, a problem still being addressed by civil engineering researchers. (41:--) Therefore, the civil engineers feel it is important to stay abreast of aircraft design changes to insure that infrastructure support requirements are met and that the environmental issues are addressed before the weapons system is fielded.

SCOPE

This paper will look at the technical developments in fighter aircraft only. The bases are assumed to be European bases. Only the maintenance support facilities built and maintained by Air Force Civil Engineers will be evaluated. Evaluation of other aircraft types and other facilities are beyond the scope of this research effort.

The Air Force is just beginning to design the ATF. Therefore, no information is available to do a detailed facility design. The ATF program goals were used to give broad guidance on design. Due to this, it is important to validate whether the goals will be achieved. This report does an extensive analysis of key technologies in order to assess the likelihood of the reliability goals actually being achieved.

The following approach will be used. Chapter Two will list the current maintenance facility support requirements for bases with F-4Es, F-15s and F-16s. Chapter Three will discuss the future requirements, and Chapter Four analyzes the technologies and shows how current facilities will change. The report will be summarized in Chapter Five.

Chapter Two

CURRENT FIGHTER MAINTENANCE FACILITIES REQUIREMENTS

INTRODUCTION

This Chapter will present details on the maintenance facilities required to support the F-4E, F-15, and F-16 units. This chapter will only deal with the maintenance support facilities that the Air Force Civil Engineers have to build and maintain. The overall objective of this chapter is to establish a baseline of present facilities requirements in order to compare them to future requirements. This will lead into the following chapters' discussion of new aircraft technologies' impact on aircraft reliability and maintenance support facilities.

MAINTENANCE ORGANIZATION

The Tactical Air Forces use the Combat Oriented Maintenance Organization (COMO) to organizie their maintenance personnel and shops. The bulk of the organization exists in three squadrons, the Aircraft Generation Squadron (AGS), the Component Repair Squadron (CRS), and the Equipment Maintenance Squadron (EMS). The personnel "assigned to the AGS perform on equipment maintenance of assigned aircraft." (26:8-1)

> The CRS primarily does off-equipment repair of aircraft and support equipment components; maintenance beyond the capability of the AGS and EMS; fabrication of parts; maintenance and operation of aircrew training devices; and repair and calibration of Test Measurement and Diagnostic Equipment (TMDE). The squadron is functionally divided into these branches: accessory maintenance, propulsion, conventional avionics, integrated avionics, aircrew training devices (ATD), and TMDE branch (26:11-1)

The EMS "is responsible for the maintenance of Flight Line Support Equipment, munitions, off equipment aircraft components, on-equipment maintenance of aircraft, and fabrication of parts." (26:18-1) The AGS, CRS, and EMS and their supporting shops are depicted in Figure One.

MAINTENANCE SHOP FACILITIES

Figure One depicts many shops. Actually, these shops are grouped together into various maintenance facilities. This section will not give the details on every facility. Rather, the facilities will be listed to give the reader an idea as to what facilities could be impacted by reliability issues. The next Chapter will identify those facilities impacted and do a detailed analysis on those facilities. Details to include square footage requirements are spelled out in Air Force Manual 86-2. Table One Lists the Shops with a Brief description of their functions. (23:8-1--8-11;39--)

Avionics maintenance facilities are particularly critical for sustained F-15 and F-16 operations. Hardened avionics maintenance facilities are being proposed for European bases. An abbreviated floor plan of a generic avionics shop is shown in Figure Two. (42:--) This facility has 1 meter thick steel reinforced concrete walls and will be buried beneath 2 meters of rock rubble and 2 meters of sand fill. The facility is designed to protect against a chemical attack. Figure Two is not drawn to scale, but the relative sizes of the shops and offices are shown. As will be shown in the next chapter, the ATF program seeks to eliminate the need for this large and expensive facility. In the figure, ATS stands for Automatic Test Station, ESS stands for Electronic Surveillance System, ECM is Electronic Counter Measures, GBU stands for Glide Bomb Unit, and MEAS is Mission Essential Avionics Systems.

SUMMARY

This purpose of this chapter was to identify the maintenance facilities required to support a fighter base. The Tactical Air Force's aircraft maintenance organization was described and its shops were listed. These will provide the baseline to analyze how increasing fighter aircraft reliability will impact shop design.

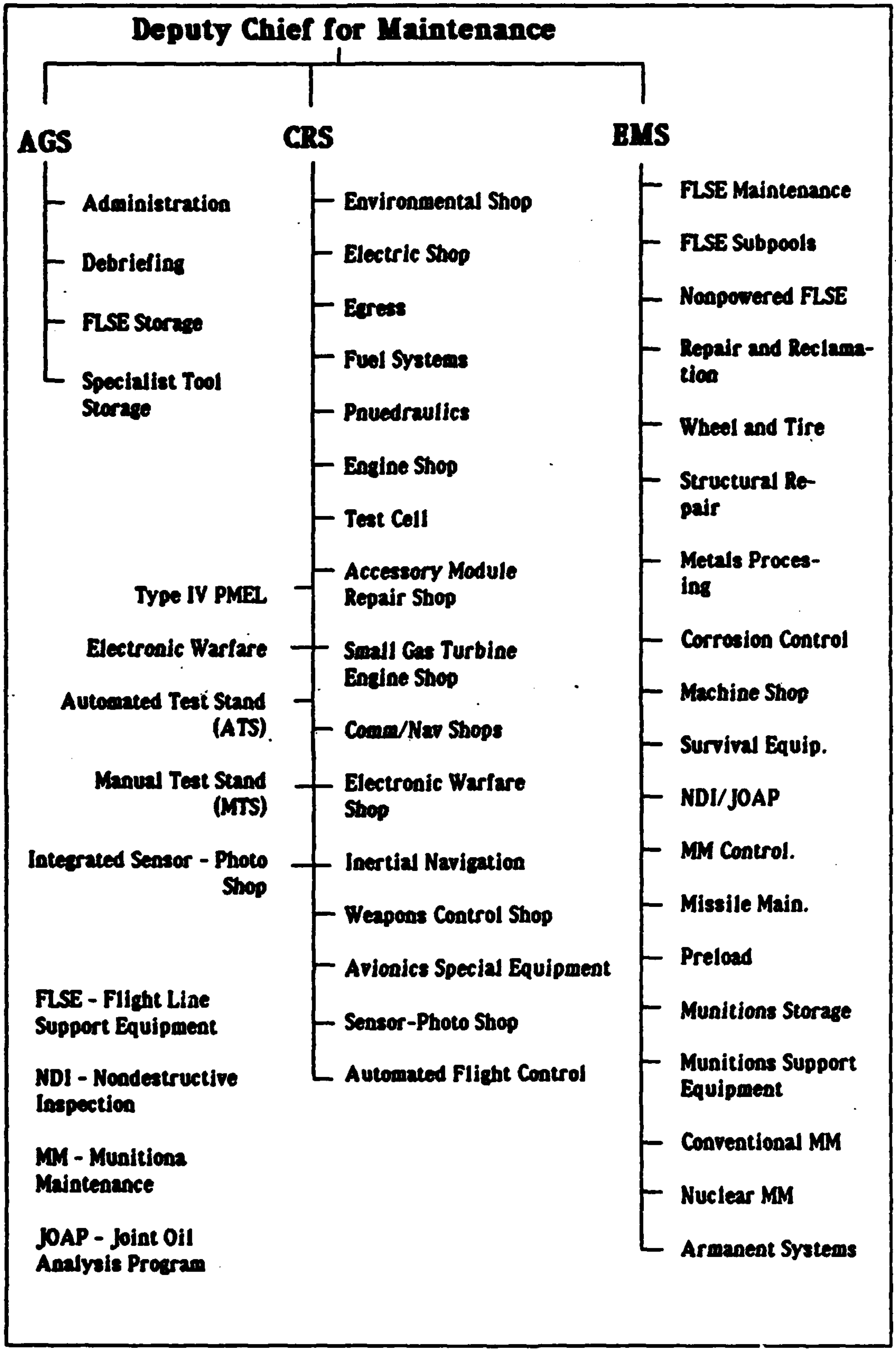


Figure 1. Maintenance Shop Organization (26:1-1--29-4)

Type Facility	Brief Description	Size
Covered Maintenance Spaces	General maintenance	7 for F-4, 6 for F-15, 6-7 for F-16 (per 24 UE Squadron (SQ))
General Purpose Aircraft Maintenance Shop	Specialized maintenance such as fabrication and reclamation	34,000 Square Feet (SF) (per fighter wing)
Nondestructive Inspection Shop	NDI testing to include X-Ray and Joint Oil Analysis Laboratory	4000 SF (per base)
Aircraft Organizational Maintenance Shop	Flightline maintenance under supervision of the Aircraft Maintenance Unit	5700 SF (per fighter SQ)
Corrosion Control Facility	Wash rack and paint shop	1 aircraft covered facility plus 11650 SF (per base)
Jet Engine Intermediate Shop	Off equipment jet engine repair	9013 to 11630 depending on aircraft type and engine (per SQ)

Table 1. Aircraft Maintenance Facilities (23:8-1--8-11;39--)

Engine Test Stand		750 SF (per base)
Engine Test Cell	Test runs and noise suppression	Large concrete facility (per base)
Missile/Glide Weapons Maintenance Shop	Missile and guided weapons maintenance	3 - 30 X 50 feet Bays plus 2500 SF administration area (per wing)
Weapons and Munitions Maintenance Shop	Weapons support equipment and ejector racks.	12100 SF (per wing)
Conventional Munitions	Munitions maintenance	3 - 30 X 50 feet bays plus 1400 SF administration area. (per wing)
Avionics Maintenance	Comm/Nav, IFF/SIF and like avionics	17000 SF (per wing)
ECM pod Shop and Storage		Variable with number of pods
PAVE TACK Pod Maintenance and Storage		Variable with number of pods
Aircraft Support Equipment Shop/Storage		Variable

Table 1. Aircraft Maintenance Facilities (Cont.)

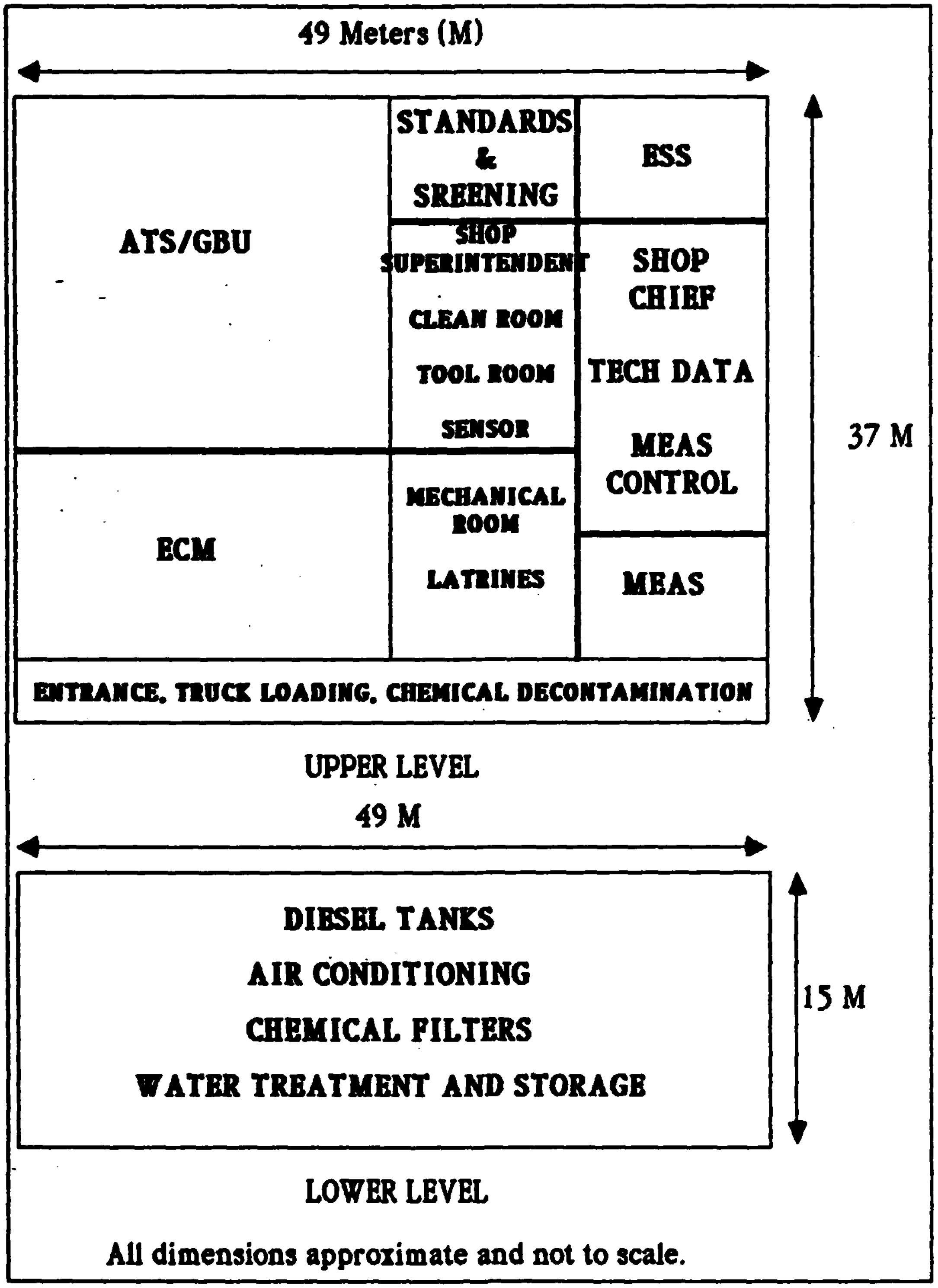


Figure 2. Generic Hardened Avionics Maintenance Shop (42--)

Chapter Three

FUTURE AIRCRAFT TECHNOLOGY

INTRODUCTION

During the past decade, the Air Force has had several programs and initiatives underway that will almost guarantee that the next fighter will be a more reliable aircraft. They are the development of MIL PRIME, the Very High Speed Integrated Circuits (VHSIC) Program, the R & M (Reliability and Maintainability) 2000 Action Plan, the Improved Performance Engine (IPE) Program, the Highly Integrated Digital Engine Control (HIDEC) Program, and the joint services integrated avionics plan mandated by the U. S. Congress. The results of these programs will be reflected in the ATF. The rest of this chapter will briefly describe each of the above programs and initiatives and show how they will impact the ATF to make it a more reliable aircraft. This chapter will also introduce some of the results of the recently completed HRF program, because this program is one of the first efforts at describing the fighter to follow the ATF. The chapter will conclude with an assessment of the likelihood of the Air Force achieving some of its aggressive fighter reliability goals. The discussion will start with a brief description of MIL PRIME.

MIL-PRIME

Aircraft weapons systems specifications are being rewritten in a format that allows requirements to be tailored for a particular weapons system, emphasizing contractor innovation and performance. The new format is called MIL-PRIME, and it is the Air Force response to the Office of Management and Budget (OMB) Circular A-109. A-109 requires "... DoD, to think more in terms of specifying mission requirements that need to be satisfied rather than in terms of the equipment needed to satisfy a mission.(30:13) MIL-PRIME requires handbooks to accompany specifications that explain the origins, the current validity of requirements, and the

government engineer responsible for the requirement. It also provides a standard for the reliability requirements of the overall aircraft system (30:15-17) MIL-PRIME should result in requirements being met because it emphasizes lessons learned from past weapons systems and forces more interaction between the contractor and the government. This will prevent antiquated and irrelevant specifications from creeping into the design of new weapons systems, allowing efficient exploitation of new technologies.

Very High Speed Integrated Circuits (VHSIC) Program

Since 1978 the Air Force has sponsored a tri-Service VHSIC program. Prior to 1978 the Air Force had to rely on chips produced on the open market. (21:62) "This work will extend the US integrated circuit capability by one or two orders of magnitude in density and throughput while incorporating the latest built in test circuits for high-performance, compact, reliable, maintainable electronic systems." (22:81) Tailoring computer chip design to meet Air Force needs is "demonstrating the most significant benefits in signal processing to enhance the ability of sensors to detect a potential target, to identify it as a friend or foe and perhaps eventually to classify it by type." (20:98) These "electronic systems under development are expected to offer unprecedented levels of performance. But, perhaps for the first time, the Air Force may also get what it has always wanted in the bargain: improvements in reliability and maintainability to match." (10:58) In addition to information processing speed, VHSICs will allow for the consolidation of Line Replaceable Units (LRUs) with Line Replaceable Modules (LRM's). A 1983 study done by Air Force Avionics Laboratory showed that replacing the F-16's LRUs with VHSIC-based LRMs would reduce the number of flight line avionics specialists by 50 per cent.and eliminate the avionics intermediate shop.(10:58). VHSICs will replace numerous circuits tailored to accomplishing specific tasks by one common integrated circuit. This will eliminate many connectors and reduce circuit connector failures, a common cause of avionics maintenance problems.

R & M 2000

On September 17, 1984, the Air Force Chief of Staff, General Charles A. Gabriel and the Secretary of the Air Force, Verne Orr sent a memorandum to the commanders of all Major Commands and Separate Operating Agencies. This Memorandum stated, "For too long, the reliability and maintainability of our weapon systems have been secondary considerations in the acquisition process. It is time to change this practice and make reliability and

maintainability primary considerations."(24:59) The memo also informed the Air Force that a working group to develop and Air Force-wide action plan, later to be called the R & M 2000 Action Plan, had been formed. The R & M 2000 Action Plan was published on 1 February 1985.

The goals of R & M 2000 are to increase combat capability, to increase survivability of the combat support structure, to decrease mobility requirements per unit, to decrease manpower requirements per unit of output, and to decrease costs.(24:2) According to the R & M 2000 process book, the R & M 2000 action plan is based on five principles. First, achieve management involvement at all levels and the conviction to take R & M seriously. Second, provide motivation to industry. Third, to communicate Air Force requirements in clear operational terms. Fourth, design for R & M at the start and insure the process is continued during development. Fifth, to insure inherent R & M are preserved during production, using feedback to insure continued improvement of products. (25:10)

To get more specific, the ultimate goal of R & M 2000 is to "achieve a minimum Mean Time Between Failure (MBTF) of 2000 operating hours relative to all operating systems in the inventory." (15:21) This is a very aggressive goal, and if achieved, this would be a giant step forward for aircraft maintenance. However, General James P. Mullins, former Commander of Air Force Logistics Command stated "The notion of building systems that don't need logistics, except consumables like fuel and munitions ... isn't pie in the sky. In fact, to a great extent, we already have this technology. The 2,000 hour MTBF is not a fantasy of the future--it's a reality today." (4:13)

Improved Performance Engine (IPE) Program

The IPE program is a follow-on program to the Alternate Fighter Engine program which produced the engines for the F-16 C/D model aircraft and the F-15 C/D model aircraft. The Air Force has built on experiences with the F100-200 engines to produce the General Electric F110-GE-100 and Pratt and Whitney F100-PW-220 engine. Reliability goals for the IPE call for the engine to be able to undergo 3000-4000 TAC cycles (1500-2000 flight hours) before major engine overhaul. A TAC cycle is defined as one full movement of the throttle from idle to Mil power. Throttle bursts form a portion of a TAC cycle and accumulate to make a full TAC cycle. There are approximately two TAC cycles per flying hours. These levels have already been achieved with the F100-200 engine which is currently averaging 5,122 hours before depot removal is required. (35:--) The IPE program hopes to

improve on the thrust-to-weight ratios of the F100-PW-220 and the F110-GE-100 engines without reducing engine reliability. An ATF program official feels the Joint Advanced Fighter Engine (JAFE) program should be able to build on IPE technologies to meet its reliability goals of 2000 hours flying time between overhauls. (37:--)

Highly Integrated Digital Engine Control (HIDEC) Program

The HIDEC program is using digital technology to control fighter engines. The goals of the program are to improve thrust, fuel efficiency, and engine reliability. Computer controls offer improved inflight performance which should reduce maintenance actions. Engines are trimmed automatically which also reduces maintenance actions and improves afterburner performance (9:74) The ATF engine will incorporate this technology and it should result in a more reliable engine. (38:--)

Joint Services Integrated Avionics Plan

"The Fiscal Year 1987 DoD Appropriations Act directed the Service Secretaries . . . to prepare a 'joint plan for the inclusion of fully integrated, digital avionics, communications, sensors, embedded communications security, and other electronics on all aircraft under development'." (11:54) The plan endorses the use of VHSICs, and the Pave Pillar integrated avionics package being developed for the ATF. The plan has also established the Joint Integrated Avionics Working Group (JIAWG) to "institutionalize tri-Service avionics planning for LHX, ATA, and ATF". (11:54) The avionics supersystems, the Integrated Communications Navigation Identification Avionics (ICNIA), and Integrated Electronic Warfare Systems (INEWS) are being developed under joint Service programs. (11:54)

Summary of Programs

Major Air Force Programs and initiatives have been described that will all play a major role in insuring that future aircraft are more reliable. This assertion can be made because all of these programs and initiatives stress reliability improvements and most have been initiated at the highest levels of the Air Force. The focus of the report will now be turned to the ATF program and its reliability goals.

ADVANCED TACTICAL FIGHTER (ATF)

According to the ATF Deputy Program Manager for Logistics, reliability is a driver in the ATF design, but not the main driver. (38:--) The research indicates that the greatest opportunities for enhancement of reliability lies in avionics development. The JAFE program is developing a new, reliable engine. The adaption of a high pressure hydraulics system for the ATF is being studied. Finally, the ATF may use an On Board Oxygen Generating System (OBOGS), which would replace the current Liquid Oxygen Systems (LOX).

Unlike its predecessors, the F-15 and F-16, the ATF is likely to require less maintenance support. The ATF program is attempting to eliminate the intermediate level maintenance shops. (38:--) In addition, the Air Force hopes to "double the sortie rate and weapons system reliability of the F-15 with half the maintenance personnel and twice the mean time between failures (MBTF)." (12:19) Another "goal is to be able to move an ATF squadron with only one-third the airlift capacity needed to deploy an F-15 squadron." (19:24)

Avionics

The ATF will be an avionics intensive aircraft. "The successful development of advanced avionics systems also will provide the primary combat performance distinguishing the ATF and ATA (Advanced Tactical Aircraft, a Navy program) from earlier fighter and attack aircraft." (12:19) In 1984 the ATF program manager said that the ATF will integrate man and machine

> to an unprecedented extent". (7:35) In a 1987 interview with Air Force Magazine the ATF program manager said, "in the ATF, we have a totally new way of viewing avionics. It's new technology, a totally new architecture. It's not black boxes. It's plug-in modules that are racked and stacked and changed according to scenarios. It's common signal processors running things, such as the radar, electronic warfare, stores management, and infrared search and track. It's VHSIC (very high speed integrated circuits) and so on. (7:12).

The ATF program endorses the PAVE Pillar Advanced Systems Integration Program concept, incorporating common modular avionics components. (38:--)

Revolutionary improvements in avionics performance and reliability will be brought about by the use of VHSICs and new electronic connector cooling technologies. Liquid cooling will be used to drive electronic circuits' junction temperatures down from the current 90-110 degrees centigrade to below 70 degrees centigrade. (38:--)

One of the primary causes of micro circuit failures is circuit junction failure. As stated above, VHSICs will reduce the number of junctions, and developing heat pipe technology will cool junctions in order to reduce heat stress. Heat pipes are sealed tubes with a liquid core. The liquid-to-vapor cycle caused by heat absorption from circuit junctions provides a mechanism to remove heat from the circuit boards. Both the RCA corporation and Hughes Aircraft have developed methods to cool avionics packages. (12:20-21) This technology will be adapted to the ATF. (38:--)

Based on the above, it can be concluded that avionics maintenance support will be crucial for the ATF. Based on the technological advancements in VHSIC, circuit cooling and the emphasis by ATF program managers, it could reasonably be expected that reductions in avionics maintenance support requirements could be achieved. This is reinforced when the high level emphasis on reliability placed on weapons system acquisition by R & M 2000 and the MIL-PRIME are considered.

ATF Engine Technology

The ATF requires a propulsion system that can sustain supersonic cruise. Because of this, a new engine has to be developed. Additional design goals are to reduce engine parts and manage engine durability margins. (38:--) This section will describe how the JAFE program will go about achieving its performance and reliability goals.

The goals in jet engine development are to increase the thrust to engine weight ratios and engine reliability. The nature of thrust production in turbojet engines requires an increase in internal engine temperatures and high engine RPM's. This places the engine designer on the horns of a dilemma. Without advances in materials technology, increasing thrust will reduce engine life. However, technology advancements are being made.

The JAFE program is building on technology gained in the Alternate Fighter Engine (AFE) program and IPE program. The AFE program has produced two engines that are capable of operating 4000 TAC cycles or approximately 2000 hours without major inspection or overhaul. (5:87) The

two AFE engines are the Pratt and Whitney F100-PW-220 and the General Electric F110-GE-100. The manager of the ATF engine logistics said that the ATF goals are to design an engine that can operate 4000 TAC cycles on the turbine (hot) section and 8000 TAC cycles on the compressor or cold section of the engine. Its reliability performance will be comparable to that of the AFE engines but not better. (37:--)

The ATF will incorporate HIDEC technology. Advancements in single crystal metallurgy has also helped to extend engine life. The AFT engine will be required to sustain supersonic cruise, but this will be done at high altitudes where internal engine stresses will be lowered due to lower internal pressures. (37--) Also, "the JAFE (Joint Advanced Fighter Engine) prototypes will be distinguished from the previous generation by a drastic reduction in the number of blades and stages, . . ." (17:733) The ATF engine program managers are very confident that the ATF engine will meet its reliability goals.

Other Systems

It will be avionics that makes the ATF different from current fighters. The literature search turned up very little information on other systems. One article said that composite materials will comprise up to 60 per cent of the ATF prototype weight. (14:64) There was no information available to determine how this will affect the structural repair shops.

Another item of concern for the environmental engineers is the hydraulic fluid being analyzed for possible use in the ATF. One program goal is to use a nonflammable hydraulic fluid. ChlorTriFloroEthalene (CTFE) is one candidate. This material may have toxicity problems and may require special handling. (38:--)

Finally, the ATF may be the first aircraft to use an On Board Oxygen Generating System (OBOGS) which would replace the current Liquid Oxygen (LOX) system. This would be a big benefit to civil engineers because of the problems encountered with LOX destroying pavement joint sealants and asphalt concrete.

HIGH RELIABILITY FIGHTER (HRF) PROGRAM

This program will only be mentioned briefly. Since this report is looking 25 years into the future, it is worth mentioning some of the technologies

being considered in the fighter aircraft beyond the ATF. The objective of the HRF program is to investigate the feasibility of designing a jet fighter that can bed down in very austere air bases,and operate autonomously "for 250 flight hours or 30 days with little or no maintenance." (27:--) The studies, recently completed by McDonnell Aircraft Company and Northrup Aircraft Company, conclude that technologies will exist to make such an aircraft a reality. MBTFs of 11 hours and a Mean Time Between Critical Failure of 40 hours is possible. This compares to the 4-8 MBTF being envisioned by the ATF program. The HRF will build on the avionics and engine design of the ATF.

The HRF may eliminate the need for a centrally distributed hydraulic system. (34:--) The centrally distributed hydraulic system, found in current fighters, has a central pump, fluid reservoir, and uses a network of tubing to distribute pressurized fluid to actuators on the control surfaces, landing gear, and other systems. This type of hydraulic system will be replaced by electric actuators, or small electric motors running numerous hydraulic pumps located at or near the actuator. There have been "three developments that have made electromechanical actuation (EMA) viable--use of rare-earth magnetic materials in 270 Vd.c. motors, highpower solid-state switching devices, and microprocessors for lightweight electronic control of actuator motor functions." (8:34) These innovations will eliminate hydraulic maintenance facilities.and hydraulic fires. This technology is not considered to be reliable enough to be incorporated on current aircraft. (8:35;36--)

To sum up, while it may be possible to eliminate many of the fixed maintenance facilities currently used by the year 2020, this is not likely to occur prior to that time frame. Fighter aircraft will still require large fixed European bases. The HRF program final report will be published in the Spring of 1988 and it is recommended that the ESL senior scientist obtain and review a copy of this report.

SUMMARY

This chapter described the Air Force programs and initiatives that are going to result in the next generation of USAF fighter weapons system being more reliable. MIL PRIME is the contracting vehicle to insure reliable systems are built and R & M 2000 is the management tool that makes reliability and maintainbility issues remain a top Air Force priority. The VHSIC program will result in full exploitation of the digital technology revolution, and the IPE program has produced powerful and reliable jet

engines. The joint services integrated avionics plan will concentrate Department of Defense efforts in avionics, resulting in greater sophistication and reliability in aircraft avionics suites.

All of these programs and initiatives will influence the design of the ATF. The ATF will be an avionics intensive aircraft with a supersonic cruise capability. The ATF program goals are to double the MBTF of the F-15, reduce maintenance manpower requirements to one-half that of the F-15, and decrease the ATF deployment airlift support requirements to one-third of that required for an F-15 squadron.

In the next chapter the likelihood of achieving the ATF and HRF program reliability goals will be examined. The impact of achieving these goals on maintenance facility design will be analyzed.

Chapter Four

IMPACT OF TECHNOLOGY

INTRODUCTION

The last chapter identified the technologies that will increase the reliability of the next generation fighter weapons system. The ATF and HRF program reliability goals were also spelled out. This chapter will analyze the likelihood of these program goals being achieved, and detail the impact of these reliability goals on the maintenance facility design. The discussion will focus on the reliability goals achievement first.

The research in this area leaves no doubt that the goals identified by the ATF and HRF programs are achievable and will occur. However, the Air Force is not likely to field the HRF within the next 20 years. To prove this, the historical trends in fighter aircraft development will be studied. It will be shown that the future goals are not out of line with the trends, and that there has been substantial gains made in technology that will improve reliability.

HISTORICAL TRENDS

Fighter Personnel Requirements

One of the ATF program goals was to reduce the number of maintenance personnel by half of that required for the F-15. Data was collected on the minimum number of people required to support a fighter operation. The data came from planning factors for deployment of a fighter unit to a forward location. This approach was chosen because it was assumed that deployment plans would utilize only the essential skills necessary to run a fighter operation. The numbers used in this section are planning factors obtained by the faculty members in the Air Command and Staff Colleges Warfare Studies Division. The original planning factors came from HQ MAC's Chief of the OPLAN Verification Division, Directorate of Operations Planning

Support. The numbers of personnel and their specialties are listed in Appendix One. Figure 3 graphically summarizes the personnel support requirements, and includes the ATF program manpower reduction goal.

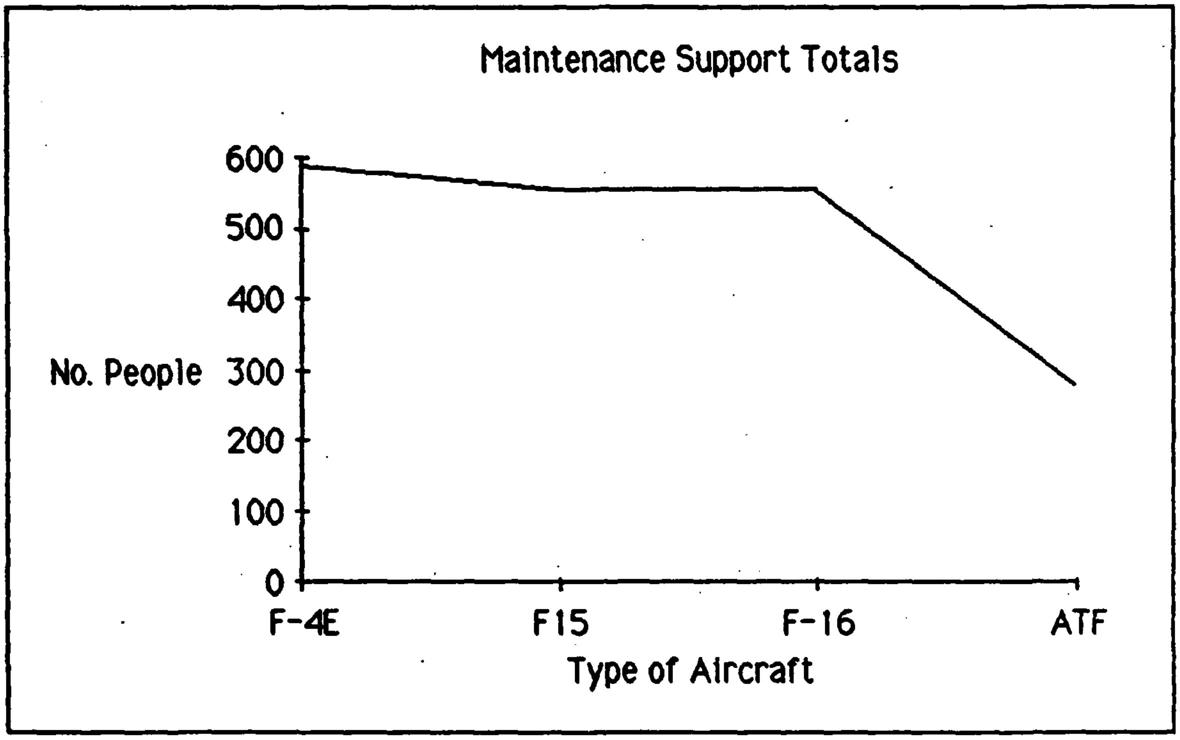


Figure 3. Fighter Unit Maintenance Personnel Requirements

It is worth analyzing what is being shown in figure 3. The F-4E, the F-15, and the F-16 aircraft have similar missions, and they show a progression of fighter development from 1967 to present. The first production F-4E was delivered to the Air Force in October 1967 (1:373-375). In November 1974 the first F-15, a B model, was delivered to the Air Force. (2:449-451) The Air Force took delivery of the first operational F-16 in January 1979. (2:410-415) A 24 Unit Equipped (UE) F-4E unit requires 588 maintenance personnel and a 24 UE F-15 A/B unit requires 554 maintenance personnel. Similarly, a 24 UE F-16A/B unit requires 551 maintenance personnel. These numbers were taken from the previously mentioned deployment planning factors. The average maintenance manpower totals are 564. The ATF would require 277 maintenance personnel. As shown in Figure 3, the Air Force has established some aggressive maintenance personnel reduction goals when compared to what has actually happened in this area over the last 20 years.

Weapons System Reliability

Much has been written about the emphasis on building more reliable aircraft. The literature on current technology certainly indicates that the achievement of the ATF goals is attainable. The goals of the HRF program can also be reached. Figure Four depicts the trends in reliability for some of the past and current fighter aircraft. The reliability for the weapons systems has been relatively low, and the doubling of the F-15 MBTFs by the ATF program does not seem out of line with the historical trends.

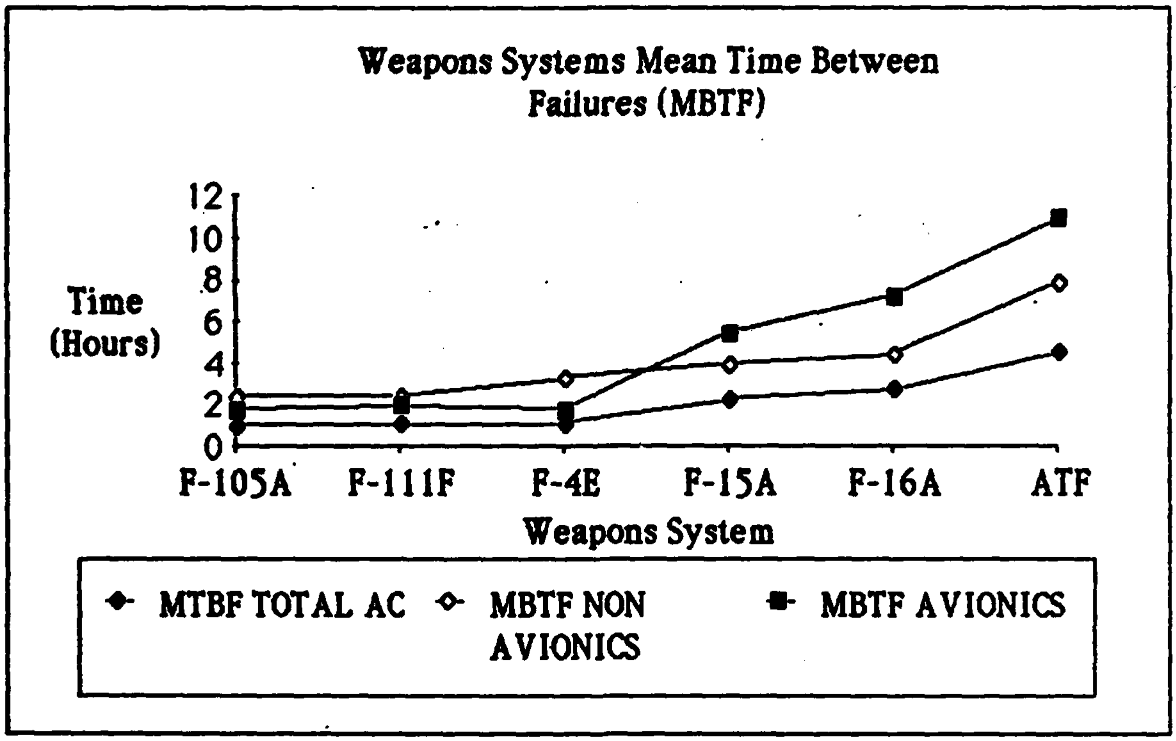


Figure 4. USAF Weapons System Reliability data (31:176)

Systems Management Considerations

This chapter has addressed the great potential for large increases in subsystem reliability. The impact on total system reliability will depend on how the system is managed once it leaves the assembly line. A hypothetical aircraft system will be used to illustrate the point.

Systems integration is a tough task. Field reliability requires a well built and designed system from the production facility. In addition, the field management of spare parts for an aircraft requires a great deal of attention. The Radar/Nav/INS subsystem in Figure 5 will be used to illustrate the need for overall systems management. Over time the radar may fail first. If it is replaced with a new radar only, this subsystem may fail again in a few flight hours if the navigation computer or inertial navigation system are also reaching their mean failure times. The point being made here is that you cannot focus on subsystem reliability figures and draw conclusions on the performance of the system. All of this has been recognized by top Air Force officials. The Aeronautical Systems Division (ASD) commander, in a 1985 interview with Aviation Week and Space Technology, emphasized that design is stressing preventative maintenance in aircraft weapons systems. (18:113-115) The difficulties in managing a weapons system's maintenance in the field are being addressed in aircraft design. The implementation of the R & M 2000 action plan should result in the successful implementation of systems management in the field.

FORCE STRUCTURE OVER THE NEXT 25 YEARS

Most of the current force of fighter aircraft will be around well into the next century. The exception to this may be the F-4 which is currently being Phased out (16:60-63) The Air Force will buy about 1,266 F-15s by the early 1990s. (2:449) The Air Force is projecting the replacement of F-15s with the ATF around 1995. 750 ATFs would be ordered at a maximum annual production rate of 72 aircraft.(13:19) The Air Force Plans to purchase 2,795 F-16s, with 1000 being delivered by 1986. (2:411) The Tactical Air Forces have a goal to obtain 40 fighter wings with 72 aircraft each, or 2880 total aircraft. (16:60-63) If it is assumed that the average age of a fighter is 20 years, then the above numbers indicate that the F-15, F-16, and ATF will comprise the bulk of the fighter force over the next 25 years. It is likely the ATF force will simply move into existing maintenance facilities without the need for construction of new facilities. The ATF beddown at current European bases will result in the closing down of many of the shops in use today and the consolidation of the maintenance functions into existing buildings.

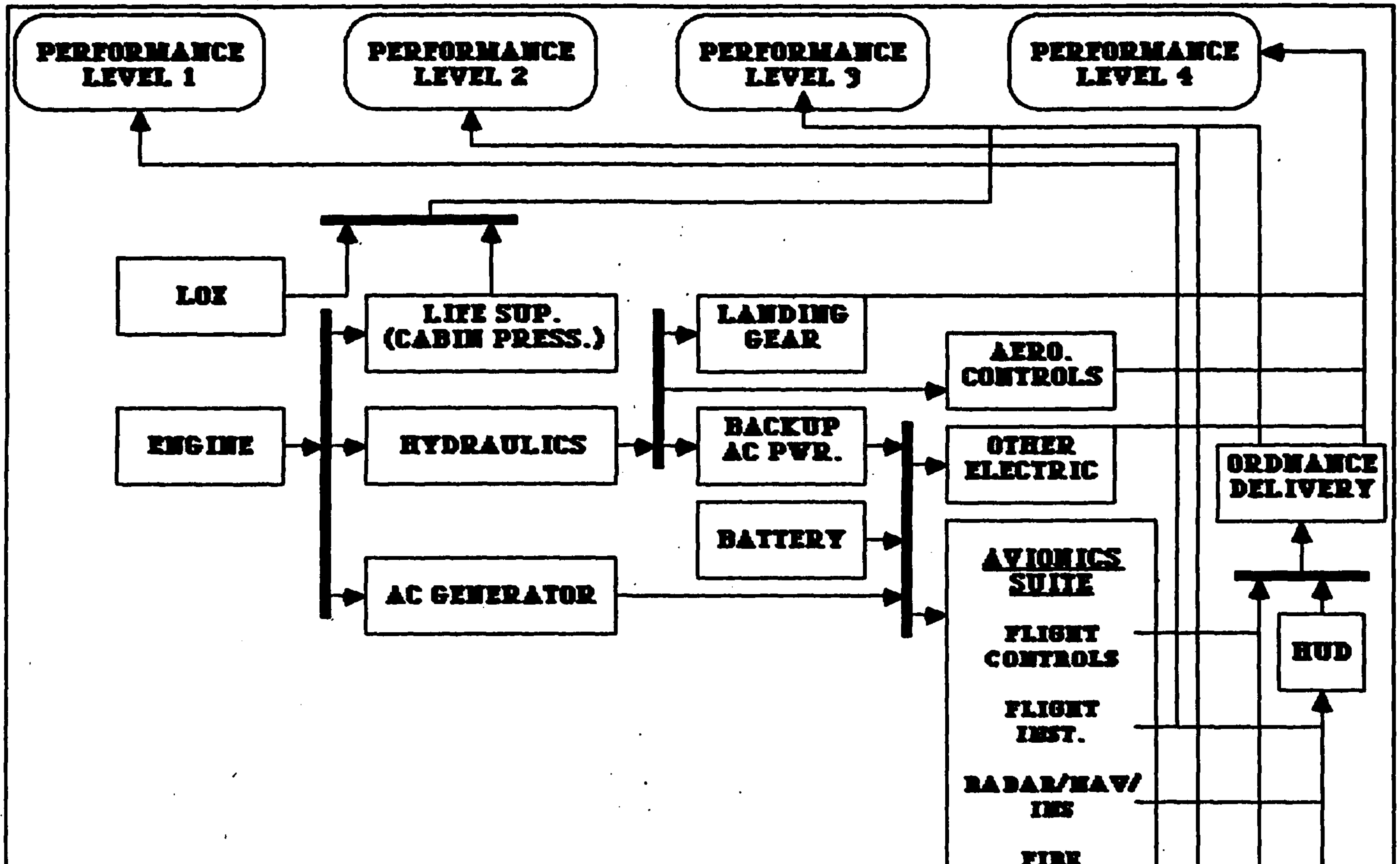


Figure 5. Simplified Aircraft Systems Diagram

IMPACT ON FACILITIES

Avionics Facilities

The rest of this chapter will concentrate on aircraft maintenance functions and their support facilities. Aircraft reliability and maintainability are primarily maintenance issues. It is accepted that the impact of reliability on manpower will affect every aspect of the base to include the size of the commissary, hospitals, etc. However these impacts are beyond the scope of this paper. In addition, a review of the data in Appendix One shows that many of the skill requirements in the operations and other base support functions will not be affected by a more reliable fighter.

The elimination of the intermediate level avionics maintenance shops is possible. However, the Air Force's High Reliability Fighter Program manager stated the total elimination of the avionics intermediate shop is unlikely. There will still be the need for the Precision Measuring Equipment Laboratory for the calibration and maintenance of Test Measurement and Diagnostic Equipment (TMDE) (36:--) Since the ATF is still in its development stage, it is too early to make a call on what the final avionics maintenance shop will look like. However, based on the HRF program managers assessment it is likely that a intermediate level avionics maintenance shop, if present, will be much smaller than the current facility. Also, due to the importance of avionics to the weapons system, any required shops will have to be survivable. This means the current desires to harden the avionics maintenance shops at European bases will be necessary for the ATF. If the facility size is reduced to just the PMEL laboratory, then the avionics shop would be reduced in size from the approximate 17000 SF shop required for current fighters. Up to an 8520 SF PMEL laboratory will still be required. (23:8-8 - 8-11) The PMEL laboratory is likely to be smaller for the ATF because some of the mobility goals will be met by using built-in test and system diagnostic equipment. If the F-15 is used as the baseline fighter to set ATF reliability requirements it would eliminate the need for 52 avionics specialist in the intermediate shop. The PMEL laboratory is currently manned by seven specialist. The reductions in shop size and personnel support requirements listed above will have a significant impact on the design and cost of any future avionics shop for the ATF. The ATF avionics shop will easily fit into the avionics shop described in the previous chapter. The extra space can be used to house the other maintenance shops required by the ATF. Therefore, shop designers should give extra thought to the location of any current shops being built in Europe. It is possible that a properly located hardened avionics shop built today for the F-15 or F-16

may house a large portion of the entire ATF maintenance complex. Anticipation of this possibility warrants a joint investigation by Air Force Civil Engineers and Maintenance Officers. Due to the permanent nature of facilities hardened for conventional bomb attacks, the future payoffs of current planning could be great.

Engine Maintenance Facilities

The Air Force's Engine Handbook and the ATF engine program provides data that can be used to compare the evolution in engine performance and reliability. This gives insight as to whether the program goals for the ATF engine are achievable. The basic engine data are listed in Table 2. T/W stand for engine thrust divided by the engine weight and ATBO means Average Time between Overhauls in hours. Table 2 lists data on jet engines from the first experimental engine developed by the Army Air Force to the engine being designed for the ATF. Only limited data was available on ATBO. In order to compare the trends in performance and reliability on the same chart, the data was normalized by dividing the value of T/W and ATBO by the maximum value of each. The results are displayed in Figure 6.

Figure 6 shows that engine reliability growth has kept up with the growth in engine performance. Materials and digital technology have been primarily responsible for this.

If properly managed, the high times between engine overhauls may eliminate the need for the engine intermediate shop. The literature search did not reveal how minor engine maintenance was to be accomplished. The F-15 was designed so that engines could be quickly removed and a spare installed in order to keep up high sortie generation rates. (30:9) The engine was then repaired in the engine shop. This technique obviated the need for an intermediate shop and engine spares to support the F-15 operations. The viability of eliminating the intermediate engine shop hinges on what type of maintenance concept is used. If an F-15 type concept is used, the shop will not be eliminated. If minor repairs are to be done on installed engines, then the intermediate engine shop can be eliminated.

Date	Aircraft	Engine	T/W	ATBO
1943	Experimental	GE TG-180	1.5	
1945	F-80	J33-A-33	2.57	
1946	F-84	J48-P5	3.12	
1949	F-100/F101	J57-P13/39	3.79	668 hours
1959	F-106 A/B	J75-P-17	4.17	
1967	F-4 E/G	J79-17A/C	4.67	849 hours
1973	F-15 A-D	F100PW100	7.77	5122 hours
1987	F-16 C/D	F110GE100	7.05	*2000 hours
1990	ATF	ATFE	9	**2000 hours

*2000 hours is the performance specification. There is not enough field data to show actual performance.

**ATF engine program goals are for 2000 hours.

Table 2. USAF Jet Fighter Engine Data (37:50-92;32:--)

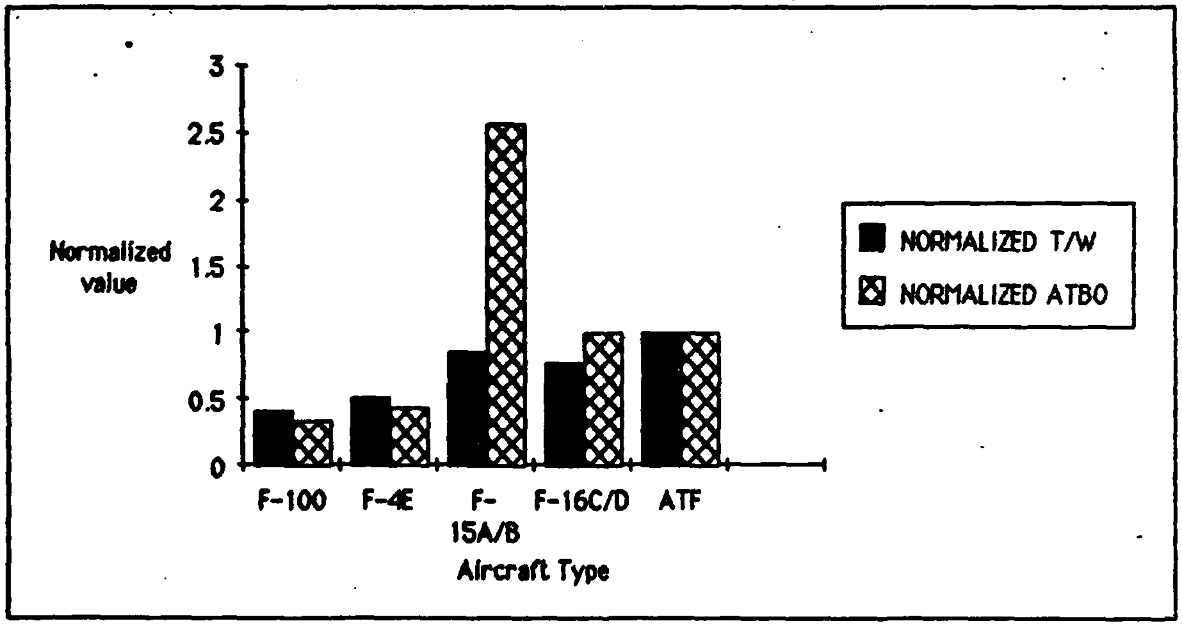


Figure 6. Fighter Engine Performance

If it assumed that some engines will have to be pulled from the ATF and repaired in an intermediate shop, it is still possible to show the reduction in shop size if the ATF program reliability goals are met. As stated earlier, the ATF program is attempting to double the reliability of the F-15. AFM 86-2 uses the following formula to calculate the authorized size of an intermediate engine shop;

$$X = ABCD/E$$

Where;

X = Total Space Requirement
A = Support Space
B = Workflow, average shop flow days per engine
C = Workload, one-half the number of installed engines in authorized aircraft.
D = Engine work space
E = Average workdays per month (22)

The F-15 with the F110 engine uses the following factors;

A=1.3, B = 16, C = 24, D =515 (35:--)

The equation solved yields 11, 686 SF. If the factor B is halved, and all other factors remain constant, the engine shop space required would be 5,483 SF. Simply put, doubling the reliability of the ATF engine over the current engine would half the intermediate shop area requirements. The F-15 intermediate shop employs 25 personnel. Meeting the ATF program goals would reduce this to 12 or 13 maintenance specialists. No unique requirements were identified. The automatic engine controls may eliminate engine trim requirements and possibly the engine test stand.

Conclusions

The Air Force is in its first year of a four year demonstration and evaluation program to build the ATF. The HRF program has been essentially a paper study. Yet many technological advancements and opportunities have been identified through various Air Force programs over the past decade that show that building a more reliable fighter is possible. This chapter has shown that the goals set in reliability seem to follow historical trends. Since the development of the F-15 there has been a more rapid growth of reliability in avionics systems, reflecting the revolution in digital technology. This technology combined with materials technology has also increased the reliability of fighter engines as well. In addition, Air Force

initiatives such as MIL-PRIME and R & M 2000 if properly implemented will insure the contractor delivers a reliable weapons system and Air Force maintenance will keep them reliable. It is all within the realm of possibility today.

Chapter Five

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This report identified the maintenance shops required to support current fighter operations in Europe. Current fighters utilize a three tier maintenance approach with on equipment maintenance, intermediate level maintenance, and depot level maintenance. The F-4E, F-15 and F-16 are very dependent on the intermediate level maintenance shops, particularly the avionics and engine shops. Because these facilities are so critical to these aircraft, they are being hardened to make these weapons systems survivable. The intermediate shops are large and their size is highly dependent on the reliability of the weapons system.

This report identified the ATF goal of eliminating intermediate shops and increasing the total weapons system reliability to double that of the F-15. The report also showed that due to technology advances and high level Air Force emphasis on reliability improvement, the ATF program is likely to achieve these goals. The ATF will not require an intermediate level avionics shop but will require a PMEL laboratory. The engine intermediate shop requirements will be greatly reduced in comparison to the F-15. However, since large hardened intermediate engine and avionics shops supporting the current weapons systems will be in place, it is likely that most of the ATF maintenance support will be housed in these facilities.

An aircraft that will be able to operate out of austere bases will not be in the inventory within the next 20-25 years, though it is possible to build such an aircraft. Therefore, Air Force civil engineers can be expected to support large fixed bases in Europe well into the next decade.

A final conclusion that fell out of this study is that future fighters will have a higher sorties rate. This will affect the sizing of fuel storage and distribution systems. The size of the weapons storage facilities and shops will also be affected.

RECOMMENDATIONS

As a result of this research, there are four recommendations for the Air Force civil engineering community. First, the hardening of intermediate level maintenance shops at European bases should continue. However, the siting of these facilities should be done so that most of the ATF maintenance organization, including the Aircraft Generation Squadron, can move into them. Second, a joint study with the maintenance personnel on siting of hardened facilities, with anticipation of future fighter occupancy should be accomplished. Third, the impact of increased sortie rates on fuels storage, fuels distribution systems, and munition storage facility sizing should be studied in another research effort. Finally, environmental engineers should study the environmental impact of using CTFE as a hydraulic fluid.

BIBLIOGRAPHY

REFERENCES CITED

Books

1. Taylor, John R. and Kenneth Munson, (eds). Jane's All the World's Aircraft 1978-79. New York: Franklin Watts Inc., 1978.

2. Taylor, John R. and Kenneth Munson, (eds). Jane's All the World's Aircraft 1986-87. New York: Jane's Publishing Inc., 1986.

Articles and Periodicals

3. "Aerospace Highlights." Aerospace America, Vol. 25, No. 12 (December 1987)

4. Bartlow, Gene S., Col. "Institutionalizing Air Force Reliability and Maintainability (R&M)." Air Force Journal of Logistics, Vol IX, No. 13 (Summer 1985).

5. Berry, F. Clifton, Jr. "2000 is (Nearly) Now." Air Force Magazine, Vol 70, No. 2 (February 1987).

6. Canan, James W. "Toward the totally integrated Airplane." Air Force Magazine, Vol 67, No. 1 (January 1984).

7. Canan, James W. "The ATF: Hot and Stealthy." Air Force Magazine, Vol 70, No. 4 (April 1987).

8. Demeis, Richard. "Control Muscle for Agile Aircraft." Aerospace America, Vol. 26, NO. 2 (February 1968)

9. Dornheim, Michael A. "Hidec Program may Provide Improved Engine Flight Profile Management." Aviation Week and Space Technology (March 11, 1985).

10. Goodman, Glenn W. "VHSIC a Potential Boon to Air Force R&M and Advanced Tactical Fighter." Armed Forces Journal, (January 1987).

CONTINUED

11. Goodman, Glenn W. Jr. "Joint Services Integrated Avionics Plan Sent to Congress." Armed Forces Journal International (July, 1987).

12. North, David M. "USAF Awards ATF Contracts to Lockheed, Northrup." Aviation Week and Space Technology (November 10, 1986).

13. Peterson, George P. "Heat Removal Key to Shrinking Avionics." Aerospace America, Vol. 25, No. 10 (October 1987).

14. Rawles, James W. "ATF Program Faces Tough Challenges." Defense Electronics, Vol. 19, No. 9 (September 1987).

15. Roder, Roy, "The Quest for Quality." Logistics Spectrum, Vol 20, Issue 1, Huntsville, AL: Society of Logistics Engineers (Spring 1986).

16. Russ, Robert D., Lt Gen, USAF. "The Fighter Roadmap." Air Force Magazine, Vol 67, No. 6 (June 1984).

17. Sweetman, Bill, Condom, Pierre, and Gilson, Charles. "Fighter Power for the 1990's." Interavia (July 1986).

18 Stein, Kenneth J. "USAF Shifts Design Philosophy to Stress Preventative Maintenance." Aviation Week and Space Technology (June 10, 1985).

19. "USAF to Request Demonstration/Validation Proposals on Advanced Tactical Fighter." Aviation Week and Space Technology (August 26, 1985).

20. "VHSIC Demonstrates Significant Benefits In Performing Signal Processing Functions." Aviation Week and Space Technology (September 7, 1987).

21. "VHSIC Program Provides DoD State-of-the Art Microchips." Armed Forces Journal (January 1987).

22. "What's Happening at ASD." Air Force Magazine, Vol 71, No. 1 (January 1988).

Official Documents

23. Headquarters Air Force. AFM 86-2, Standard Facility Requirements. HQ USAF, Washington DC: HQ USAF/LEEE, 4 May 1987.

24. Headquarters Air Force, USAF R&M Action Plan Development Team Final Report, Volume 1, HQ USAF, Washington DC: HQ USAF/LE-RD, February 1985.

25. Headquarters Air Force, USAF R&M Process, HQ USAF, Washington DC: HQ USAF/LE-RD, October 1987.

26. Headquarters Tactical Air Command. TACR 66-5 (Also MCR 66-5), Combat Oriented Maintenance Organization. Langley AFB, VA: HQ TAC/LGMP September 1985.

27. "High Reliability Fighter Program Research and Technology Work Unit Summary". Accession Number DF 484009, Report Control Number MWI41E. Defense Technical Information Center, Cameron Station, VA, 1 Jul 87.

28. Howard, Christopher E., Capt, USAF, Evaluation of F-15 Operations and Maintenance Costs Based on Analysis of Category II Test Program Maintenance Data. Air Force Institute of Technology, Wright Patterson AFB, OH, August 1975.

29. Office of the Secretary of the Air Force, "Air Force Policy Letter for Commanders", Washington DC: 15 May 1985.

30. Stearman, Ricky T., Capt, USAF and Weber, Warren E., Major, USAF. An Evaluation of MIL PRIME in Comparison with the Traditional Specification System. School of Logistics, Air Force Institute of Technology, Wright Patterson AFB, OH: June 1981.

31. US Air Force Logistics Command, The Logistics of Waging War, Rutenberg, David C. Lt Col, USAF and Allen, Jane S. Ed., Gunter AFS, AL: AFLMC, 1987.

32. US Air Force Logistics Command, "USAF Aircraft Gas and Reciprocating Engines", Engine Handbook, Wright Patterson AFB, OH: AFLC LOC/PNA, January, 1987.

Other Sources

33. Denbleyker, Ken, Major, USAF. Research Engineer, Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center, Tyndall AFB, FL. Telecon, 19 February 1988.

34. High Reliability Fighter Program Final Contractor Briefings, ASD/XRS, Wright Patterson AFB, OH.

35. Iacabucci, Rick. Deputy for Engine Logistics, Air Force Logistics Command, Logistics Operation Center, AFLC LOC/PN, Wright Patterson AFB, OH. Telecon, 19 February 1988.

36. Kosan, Jeffrey D., High Reliability Fighter Program Manager, Deputy for Development Planning, Aeronautical Systems Division, Wright Patterson AFB, OH. Telecon, 3 February, 1988.

37. Mapes, Don, ATF Program Office, Engine Logistics, Aeronautical Systems Division, Wright Patterson AFB, OH. Telecon, 5 February, 1988.

38. May, T., Lt Col, USAF, Advanced Tactical Fighter Deputy Program Manager for Logistics, Aeronautical Systems Division, Wright Patterson AFB, OH. Telecon, 5 February, 1988.

39. Robey, B. F., AF/LEXP, Revision to AFM 86-2 to be incorporated in Spring of 1988.

40. Strickland, W. Stan, GS-14. Chief Structures Research Branch, Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center, Tyndall AFB, FL. Telecon, 4 January 1988.

41. Walrond, George E. Major, USAF. Former Chief Pavements Research Branch, Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center, Tyndall AFB, FL.

CONTINUED

42. Walton, Bruce, GS-13. Research Engineer, Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center, Tyndall AFB, FL. Telecon, 19 February 1988.

GLOSSARY

AFESC	-Air Force Engineering and Services Center
AGS	-Aircraft Generation Squadron
ATA	-Advanced Tactical Aircraft
ATD	-Aircrew Training Devices
ATF	-Advanced Tactical Fighter
ATS	-Automated Test Stand
COMO	-Combat Oriented Maintenance Organization
CRS	-Component Repair Squadron
ECM	-Electronic Counter Measures
EMS	-Equipment Maintenance Squadron
ESL	-Engineering and Services Laboratory
ESS	-Electronic Surveillance System
FLSE	-Flight Line Support Equipment
HIDEC	-Highly Integrated Digital Engine Control
HRF	-High Reliability Fighter
ICNIA	-Integrated Communications Navigation Identification Avionics
INEWS	-Integrated Electronic Warfare Systems
IPE	-Increased Performance Engine
JAFE	-Joint Advanced Fighter Engine
JIAWG	-Joint Integrated Avionics Working Group
JOAP	-Joint Oil Analysis Program
LHX	-Light Helicopter Experimental
LOX	-Liquid Oxygen
MEAS	-Mission Essential Avionics Systems
MTS	-Manual Test Stand
NDE	-Nondestructive Evaluation
NDI	-Nondestructive Inspection
OBOGS	-On Board Oxygen Generating System
PMEL	-Precision Measuring Equipment Laboratory
PSI	-Pounds Per Square Inch
R & M	-Reliability and Maintainability
SON	-Statement of Need
TAFSON	-Tactical Air Force's Statement of Need
TMDE	-Test Measurement and Diagnostic Equipment

CONTINUED

VHSIC -Very High Speed Integrated Circuits

APPENDIX

Fighter Aircraft Squadron Deployment Requirements

	Type Aircraft		
Job Description	F-4E	F-15	F-16
Squadron Command	2	2	1
Squadron Section	5	4	2
Personnel	2	2	2
Operations	5	5	7
Unit Life Support	8	6	6
Aircraft Crew	60	30	32
Photo	4	2	3
Intelligence	2	6	2
Special Assessment Mgt.	8	6	6
Flight Medicine	4	4	3
Chief of Maintenance	13	11	6
Quality Control	10	11	6
Maintenance Control	17	14	7
AGE	22	35	16
Maintenance Inspection	16	12	
Repair Reclamation	8	11	3
Armament Systems	6	6	12
Structural Repair	4	1	1
Survival Equipment	4	1	2
Nondestructive Inspection	4	6	4
Corrosive Control	3	4	1
Aircraft Maintenance	23	39	23
Aircraft	50	69	73
Specialist	90	110	73
Weapons	57	62	70
Jet Engine	14	3	1
Auto Test STM		23	
Man Test STM		15	
Photo	2	4	4
PMEL	2	7	
Electronic Warfare	29	8	11
Accessory Maintenance		1	1
Pneudraulics	2	1	2
Egress	9	5	7
Fuel Systems	19	13	11
Electrical Systems	4		
Integrated Avionics			1
Equipment Maintenance	2		4
Support			7
Machine Shop	2		1
Metals Processing	2		
Environmental	2		
Avionics AGE Maintenance	2		
Comm/Nav/INS/Autopilot	6		
Integrated INS/Flt Controls			1

CONTINUED

Aircraft Generation	4		6
A/C Gen Maint. Sup.	4		
Weapons Control Systems	4		
Component Repair	8		1
Missile Maintenance	17		
Munitions Management	18		
Totals	579	539	419

Intermediate Level Maintenance

Job Description	F-4E	F-15	F-16
Quality Control	1	1	2
Maintenance Control		3	2
Inspection			8
Metals Processing		2	1
Machine Shop			1
Corrosive Control			2
Propulsion		3	
Jet Engine		19	
Pnuedraulics		2	2
Environmental Systems		2	3
Electric Integrated Avionics		2	
Electric			4
AGE	5		9
Repair Reclamation	2		
Aircraft	15		1
Component Repair			4
Inertial Nav System (INS)	1		
Sensor	3		
Electronic Warfare	2		
Weapons Control System	2		
Jet Engine	3		23
Auto Test Station			19
PMEL			8
Test Cell			4
Egress	2		
Fuel Systems	1		5
Totals	37	34	98

Other Support

Job Description	F-4E	F-15	F-16
Battle Damage Repair Engine	2	3	2
Battle Damage Repair Battle	29	31	31
Battle Damage Repair AE	2	1	1
Munitions Maintenance		52	
Chaplain	3	3	3

CONTINUED

Disaster Preparation	8	8	8
Supply Reception	20	20	20
Personnel	7	7	7
Post Office	1	1	1
Security Police	44	44	44
OSI	6	6	6
Weather Forecasting	3	3	3
Graphics	5	5	5
EOD	4	4	4
Transportation	31	31	31
POL	22	22	22
HQS Wing	21	21	21
Food Services	34	34	34
Laundry/Billeting	3	3	3
Comptroller	8	8	8
Troop Issue (PRIME FARE)	5	5	5
PRIME BEEF	200	200	200
PRIME BEEF Fire	45	45	45
Combat Support Initial	16	16	16
Totals	519	573	520

Tonnage Totals (Short Tons)

Total Bulk	198.3	237.2	259.8
Total Oversized	297.9	169.2	274.5
Maintenance Bulk	153.4	192.3	215.3
Maintenance Oversized	297.9	169.2	274.5
MMS Bulk	6.6	7.3	0.4
MMS Oversized	119.5	39.2	128.3
Total Tonnage	496.2	406.4	534.3

The numbers used in this section are planning factors obtained by the faculty members in the Air Command and Staff Colleges Warfare Studies Division. The original planning factors came from HQ MAC's Chief of the OPLAN Verification Division, Directorate of Operations Planning Support.

END
DATE
FILMED
8-88
DTIC